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Ask the Experts

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Providing answers to science questions
Send questions to Department Editor
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Q What does "spin" refer to in particle physics? Why is this concept necessary?

Danny, Student
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A To answer this question, let's start with some classical mechanic concepts. Angular momentum is the rotational analog of (linear) momentum. An everyday object that is spinning has angular momentum. If we attach electric charge to that spinning object, the circulating charge acts like a loop of current, and produces a magnetic dipole—a tiny electromagnet.

Because an electron has angular momentum and a magnetic dipole, it is natural to talk of its spin. Natural, but somewhat misleading, because on such a small scale, quantum mechanics, rather than classical mechanics, describes what happens. Like the energy of electrons in an atom, the spin of a fundamental particle is quantized: only discrete values are allowed (+1/2 and −1/2). Bear in mind, electrons do not behave like tennis balls.

Spin is a necessary concept because it is measurable. If we apply an external magnetic field, the energy of an electron is increased or decreased depending on the orientation of its dipole to the field and its spin. Spin also provides particles with an extra quantum number. The Pauli exclusion principle forbids electrons to have the same quantum numbers. Therefore, for any energy level in the atom, there can be as many as two electrons with opposite spin. Thus, spin accounts for the coexistence of twice as many electrons, which has very considerable consequences for the periodic table and chemistry.

Q My physics teacher tells me that when I go around a sharp curve in my car, there is no force causing me to move away from the center of curvature. So what is happening to make me feel as if I am sliding toward the outside?

Physics student
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(Courtesy of Teacher: Wayne Fisher)

A Let's imagine that the car is a convertible and I am watching you from above. Before the curve, the car is coasting and you and it are traveling in a straight line, with no horizontal forces acting on you or the car. Now the car turns to the left. It does this because the friction between the road and the tires produces a force acting toward the center of the curve (a centripetal force). If the road surface was covered with ice so as to remove that friction, the car would slide along in a straight line.

Now I look at you inside the car. For an instant after the car swerves to the left, you continue in your straight line. The car seat slides under you: the car is curving and you are not. But this happens only for a short time. The sliding of the seat under you brings the raised edge of the seat against your thigh, and perhaps the seat belt against your chest. These lateral forces exerted by the seat edge and the seat belt push you around the corner—they provide the centripetal force.

Before the curve, you and the car are traveling north; afterward you are traveling west. Velocity is a vector (it has both magnitude and direction), so your velocity has changed. The force that changed your velocity is the centripetal force. For the car, it was the friction from the road, but for you it was the lateral force from the seat and seatbelt.

So, why does it feel as though you are being pushed outward? Well, you can feel the forces exerted by the seat and the seat belt as they accelerate you around the corner. If I were to push you outward, the forces from the seat and seat belt would limit your motion by producing forces similar to those that are accelerating you when you curve. So, if you don't think about your acceleration, you might attribute the seat and seatbelt forces to a reaction against some mysterious force that was pushing you sideways.

For more information, visit the Einstein Light website (see "Galileo: Inertial Frames") at *www.phys.unsw.edu.au/einsteinlight*.

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(In your e-mail, please include your name, school, and address.)